An Overview of Mosquito Control in Delaware

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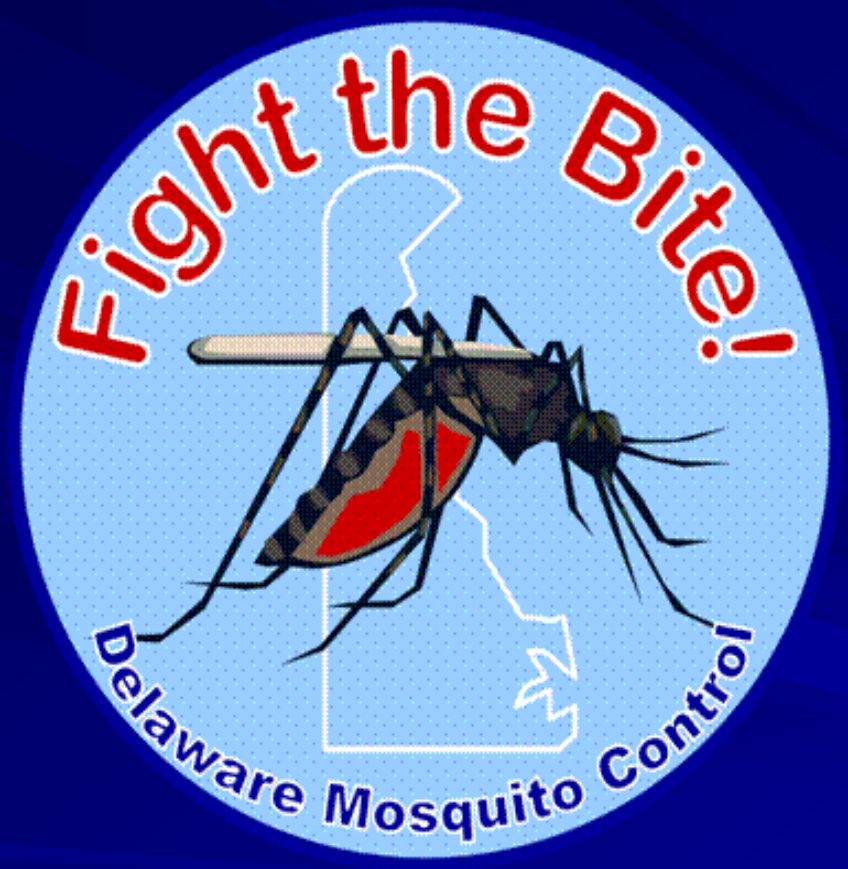
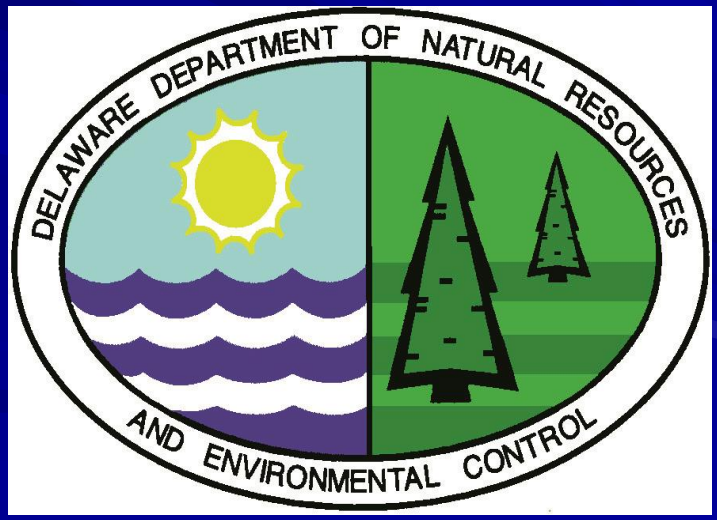

Fight the Bite!
Delaware Mosquito Control


DELAWARE DIVISION
FISH & WILDLIFE


DELAWARE DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL

Why Control Mosquitoes?

- Quality-of-life considerations – nuisance, annoyance, pestilence (probably the primary reason for the public's expecting/demanding control actions, and paying for such via their taxes).

- Adverse impacts to local economies based:
  - Tourism (lodging/hotels, food/restaurants, shopping, attractions; 1959 Cape May EEE outbreak)
  - Outdoor events (sports events, festivals, concerts, fireworks)
  - Outdoor recreation (camping, hiking, hunting, fishing, boating, canoeing/kayaking, birding, etc.)
  - Animal husbandry (dairy production, cattle, swine, fowl, horses; exsanguination of cattle in Texas after hurricanes)

- Maintain property values (nobody wants to live or buy into a mosquito-infested neighborhood – realtors, bankers, builders)

- Public or human health concerns/threat (but more of an "abstract" issue to most people) – see next slide.

Public or human health concerns/threats

- Mosquito bites per se (without pathogen transmission) – important to recognize!
  - dermal irritation
  - local or systemic allergenic reactions
  - secondary infections at bite sites (especially kids' scratching)
  - mental health impacts (anguish, torment)

- Mosquito-borne diseases affecting humans:
  - **Eastern equine encephalitis** (EEE) and **West Nile virus** (WNV) are primary arbovirus concerns in Delaware (elsewhere in country also concerned with western equine, St. Louis, and LaCrosse encephalitis).
  - **Malaria** (world-wide killer, used to be endemic in Delaware; Dickinson plantation avoidance; Civil War impacts, including Fort Delaware); worldwide 200 million new cases each year, 500,000 deaths.
  - **Yellow fever** (used to ravage seaports along Atlantic coast; Philadelphia epidemic in 1793; Haiti outbreak in 1802, effect on Louisiana purchase)
  - **Dengue fever** (a.k.a. breakbone fever – tropical/semi-tropical illness including Caribbean, south Florida and Texas – someday further north?); worldwide 50 million new cases each year, 25,000 deaths.
  - **Chikungunya** (last year in Caribbean, now spreading in C.A., S.A., U.S.)
  - **Filariasis** (a.k.a. elephantiasis, from filarial platyhelminth worms)

- Mosquito-borne diseases affecting animals:
  - EEE and WNV in horses – effective equine vaccines are available
  - Canine heartworm in dogs (parasitic nematode) – ivermectin preventative pills

Mosquito Life Cycle

Eggs

Larva

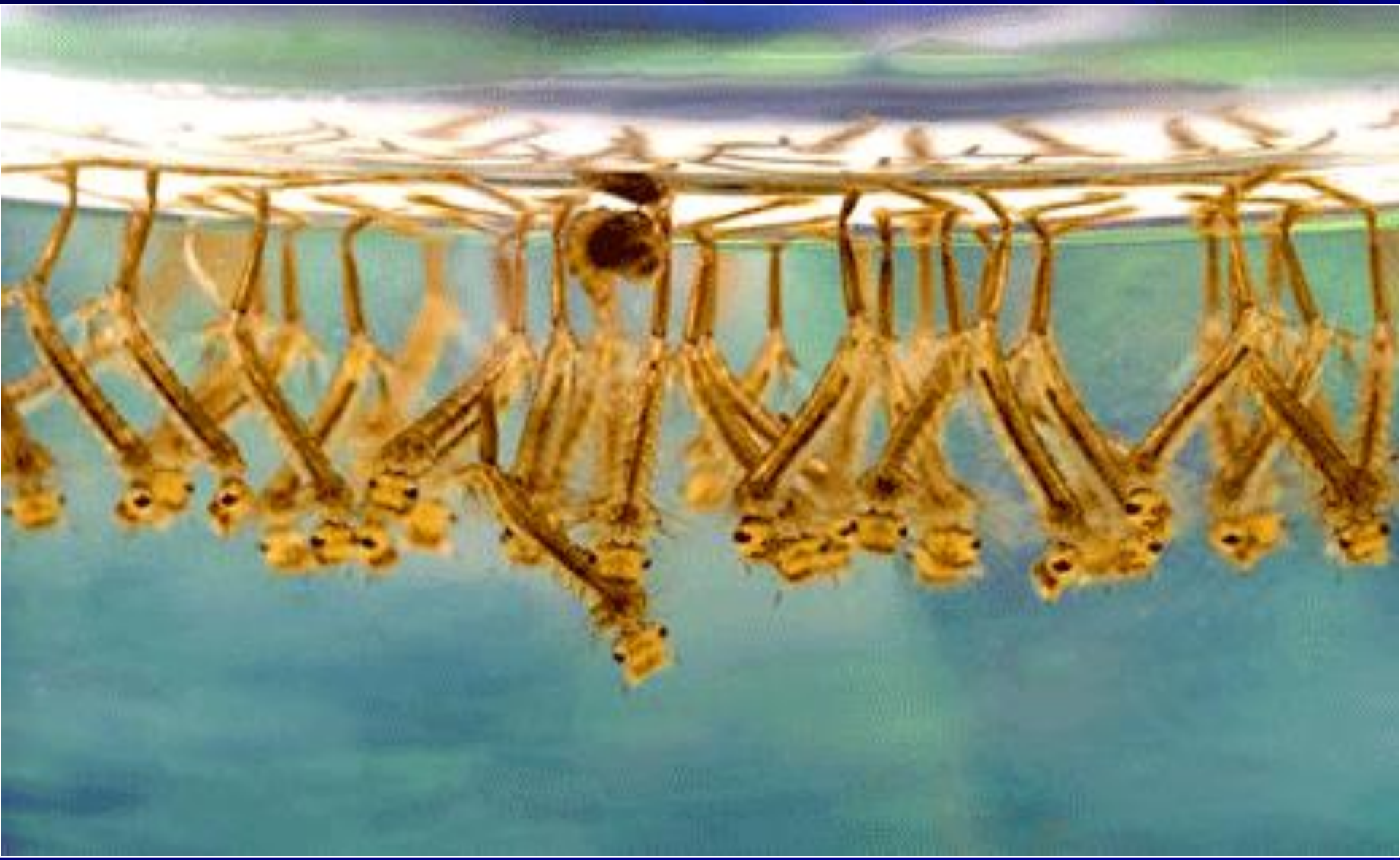
Pupa

Adult

Female uses protein in blood to develop eggs

Female laying egg raft

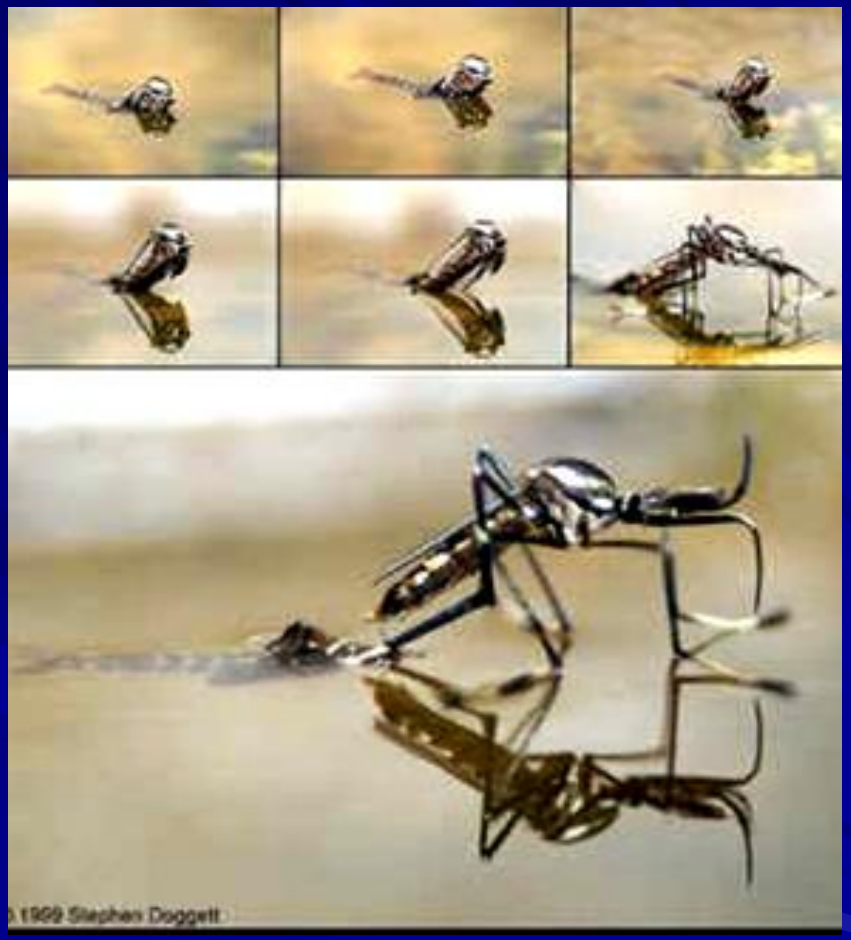
Larvae hatching from egg raft



Larvae

Pupa

Adult emerging from pupal case



Clean Up That Rubbish Pile! Mosquitoes Breed in Old Tin Cans

Bassinet for southern house mosquito's babies may be a barrel or old bottle. The female lays a raft of 150 eggs (upper left). *Culex quinquefasciatus* is one of the species in the Tropics which spread elephantiasis.

Ever Slap a Skeeter at the Seashore? Here Is Where the Villains Come From

These salt-marsh mosquitoes (*Aedes sollicitans*) lay their eggs on damp ground, to hatch when high tides cover them. The newly hatched wigglers grow water, for all mosquito larvae are aquatic. They are called wigglers because of the way they swim. Larvae have changed to pupae in lower right. Wh adult mosquitoes emerge, they will head for the nearest summer resort. Every seaside vacationer knows what they do when they get there.

Are All Mosquitoes the Same?

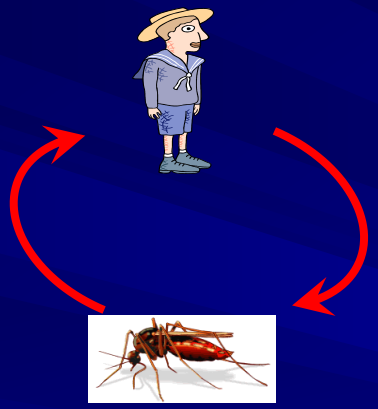
- 57 species of mosquitoes in Delaware.
- 19 species are pestiferous and/or disease-vectoring, and hence of concern to control.
- Control considerations:
  - Nuisance biters and/or disease vectors.
  - Aquatic breeding habitats – salt marshes, tidal wetlands, riverine floodplains, woodland pools, freshwater marshes, swales in wet meadows, pitcher plants, treeholes, rockpools, dredge spoil areas, stormwater ponds, sewers, man-made containers.
  - Feeding preferences – avian, mammalian, reptilian, combination.
  - Flight distances – from 100 yards up to 15-20 miles.
  - Season of occurrence – spring species, summer-fall species, all season species (April thru October).
  - Activity periods – daytime biters, crepuscular species (dusk/dawn), nocturnal species, diurnal species (day/night).

Trouble Spots!

Super-Breeding Sites!

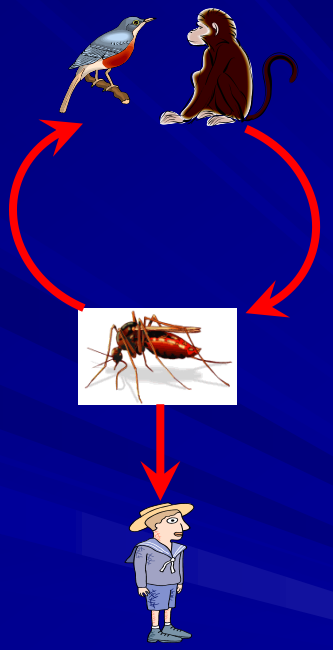
Basic Patterns of Mosquito-Borne Disease Transmission

Humans are primary hosts



Malaria - *Plasmodium* protozoan parasite
Yellow fever (urban) - flavivirus
Dengue fever - flavivirus
Chikungunya – alphavirus

Humans are incidental hosts

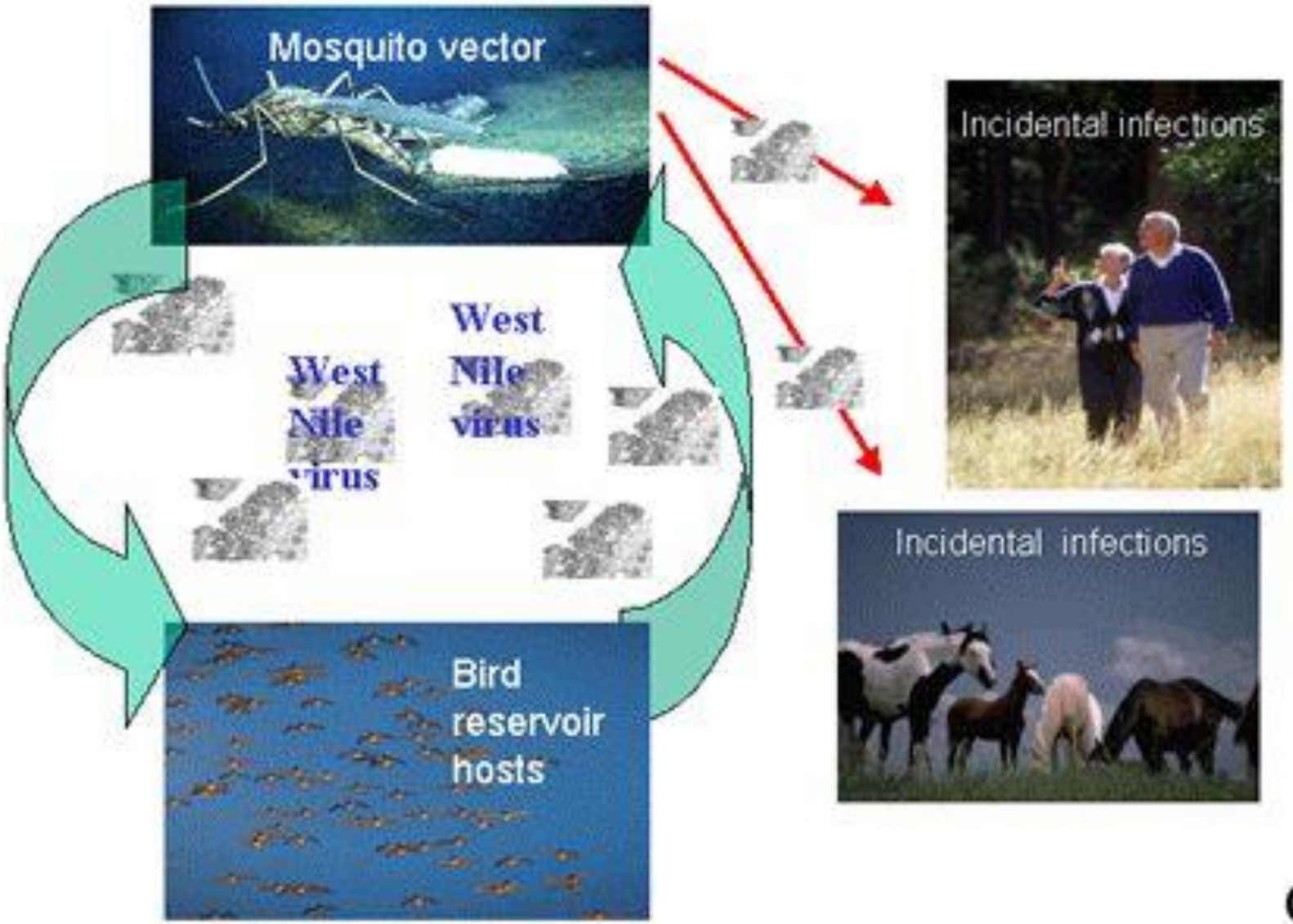


Yellow fever (sylvan) – flavivirus
EEE, WEE, VEE – alphaviruses
WNV, SLE, JEV – flaviviruses
LACV, Rift Valley – bunyavirus

Mosquito-borne Diseases
Some Important Terms

- **Vector** – an agent or organism that transmits pathogens (such as mosquitoes!)
- **Pathogen** – any microorganism or virus that causes disease (such as WNV or EEE viruses, or *Plasmodium* parasites, all borne by mosquitoes!)
- **Host** – an organism that serves as a reservoir for pathogens, typically with no adverse effects to host (many species of wild birds for WNV); but depending upon specific host-pathogen relationships, in some cases in delayed manner there can also be sickening or lethal effects for the host (e.g. some species of wild birds for WNV).
- **Dead-end Host** – an organism that contracts a vector-borne disease that can be either fatal or non-fatal, but they don't serve to further help cycle disease – dead-end host doesn't become viremic enough (e.g. humans or horses relative to EEE or WNV).
- **Bridge Vector** – a vector that transmit pathogens from normal host sources to dead-end hosts (e.g. saltmarsh mosquitoes for EEE transmission from birds to humans).
- **Arboviral disease** – *arthropod-borne* (hence "arbo") viral diseases (such as spread by mosquitoes!)
- **Virus families** – 96 recognized virus families – virus classification based on morphology, nucleic acid type, mode of reproduction, host organisms, types of disease caused. The 3 most important virus families for mosquito-borne encephalitis diseases are alphaviruses, flaviviruses and bunyaviruses.

West Nile Virus Transmission Cycle



Facts about West Nile virus

- Most WNV-infected humans (80%) are asymptomatic. Smaller proportion (20%) develop mild symptoms – low fever, headache, body aches, skin rash, swollen lymph glands.

- About 0.5%-1.0% of all people infected with WNV develop more serious manifestations -- elderly or people with compromised immune systems most prone.

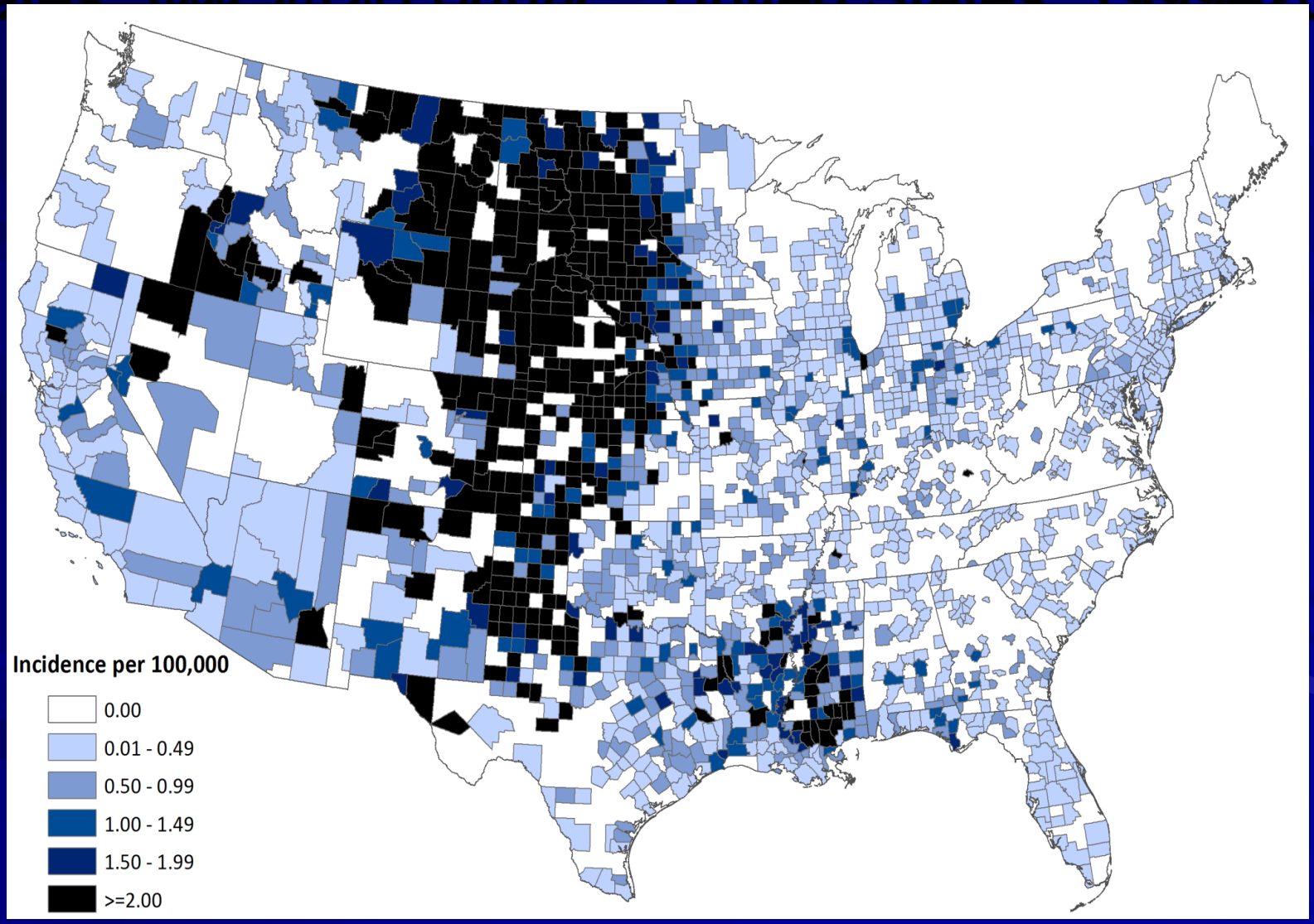
- More serious manifestations can -- severe headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, flaccid paralysis.

- Among those with severe symptoms, fatality rate around 5% (or only 0.025%-0.05% of all WNV-infected people). Primary cause of death = encephalitis (swelling of the brain). Long-term neurological problems also occur.

incidence of WNV severe neurological disease

Average incidence/rate of WNV severe neurological disease per 100,000 residents by county, 1999-2012

unty – United States, 1999–2012



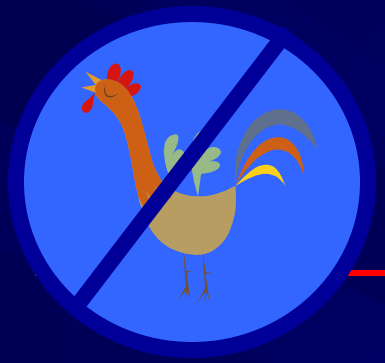
West Nile virus disease cases and deaths reported to CDC by year and clinical presentation, 1999-2013

Year	Neuroinvasive disease		Non-neuroinvasive disease		Totals	
	Cases	Deaths	Cases	Deaths	Cases	Deaths
1999	59	7	3	0	62	7
2000	19	2	2	0	21	2
2001	64	10	2	0	66	10
2002	2,946	276	1,210	8	4,156	284
2003	2,866	232	6,996	32	9,862	264
2004	1,148	94	1,391	6	2,539	100
2005	1,309	104	1,691	15	3,000	119
2006	1,495	162	2,774	15	4,269	177
2007	1,227	117	2,403	7	3,630	124
2008	689	41	667	3	1,356	44
2009	386	32	334	0	720	32
2010	629	54	392	3	1,021	57
2011	486	42	226	1	712	43
2012	2,873	270	2,801	16	5,674	286
2013	1,267	111	1,202	8	2,469	119
Totals	**17,463**	**1,554**	**22,094**	**114**	**39,557**	**1,668**
2014	*732*	---	*569*	---	*1,301*	*47*

Arbovirus in Delaware

Year	WNV Chik	EEE Chik	WNV Bird	WNV Horse	EEE Horse	WNV Human
2000	0	1	1	4	0	0
2001	0	2	34	4	0	0
2002	11	0	210	20	0	1
2003	34	8	113	62	1	17 (2 deaths)
2004	16	4	22	0	4	0
2005	5	2	--	--	--	2
2006	18	0	--	--	--	0
2007	18	0	--	--	--	1
2008	18	4	--	--	--	1
2009	15	0	--	--	--	0
2010	15	0	--	--	--	0
2011	5	0	--	--	--	1
2012	37	0	21	--	--	9 (1 death)
2013	22	1	17	6	2	3
2014	8	0	4	0	0	0


DO NOT DISTURB

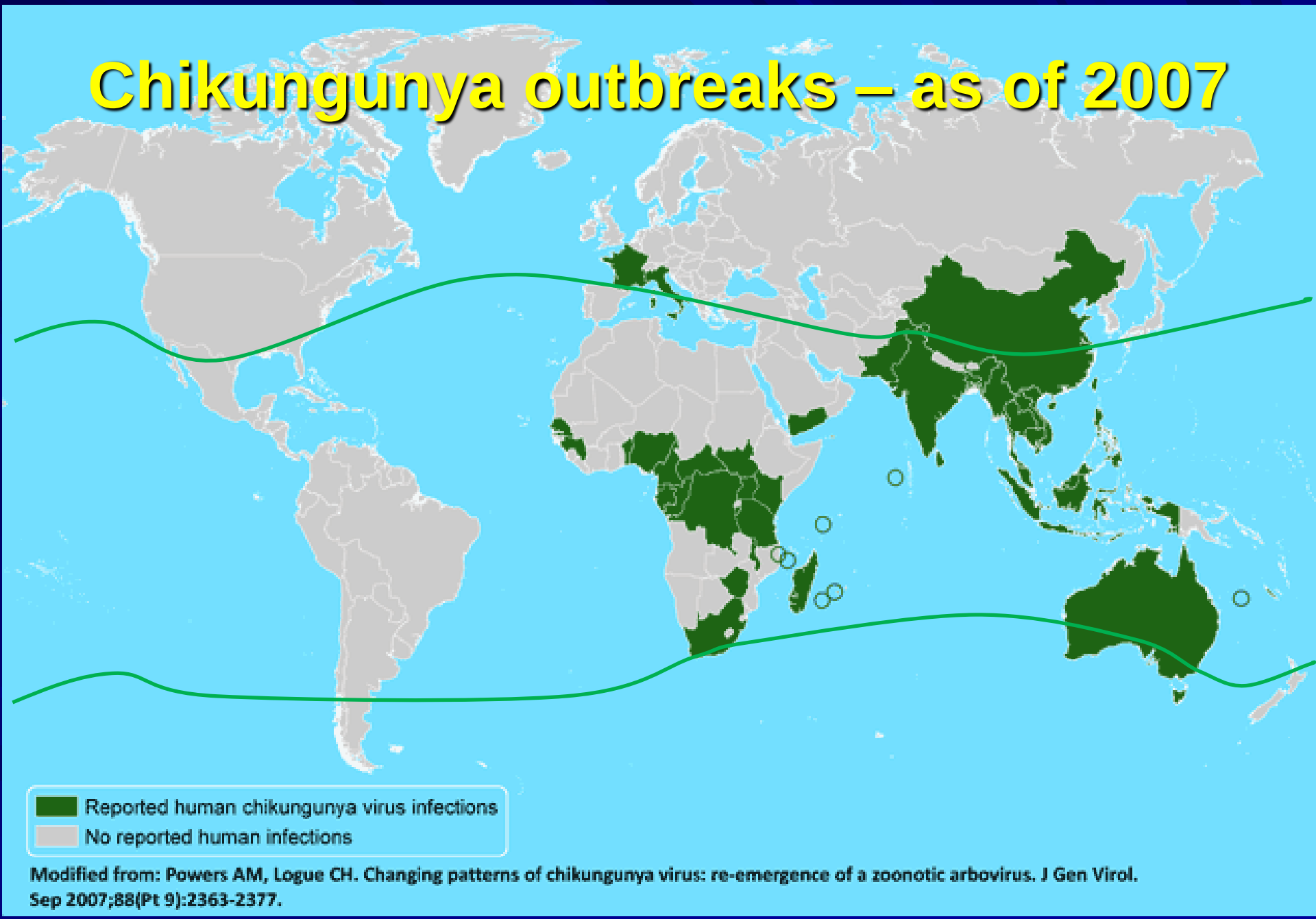


Chikungunya virus: the latest threat
Makonde language “to dry up or become contorted”

- 3 genotypes
  - West African
  - East African/Indian Ocean (also cause of recent outbreaks in Italy and France, involving transmissions by Asian tiger mosquitoes)
  - Asian (strain that jumped to Caribbean in 2013 and is spreading throughout Central and South America, and also into U.S. too, primarily as imported Chik cases for the latter)

- Chikungunya much like dengue for transmission
  - Man-mosquito-man transmission cycle
  - Yellow fever mosquito, *Aedes aegypti,* is the traditional urban vector for Chik
  - Also spread by Asian tiger mosquito, *Aedes albopictus* (*new news* – ATMs are vector competent for the Asian strain now in Western Hemisphere, no mutation of this strain is necessary)

Chikungunya outbreaks – as of 2007



Modified from: Powers AM, Logue CH. Changing patterns of chikungunya virus: re-emergence of a zoonotic arbovirus. J Gen Virol. Sep 2007;88(Pt 9):2363-2377.

Chikungunya in the Western Hemisphere Started in Caribbean in 2013

- First identified in St. Martin in December, 2013
- As of early May, 2014 – 6000 suspect cases in 15 Caribbean countries or territories + French Guinea
- Genetic evidence indicates importation from Asia/Pacific

Current Status of Chikungunya in Western Hemisphere

- As of 10/3/14 in Western Hemisphere:
  - 739,410 suspect cases (as opposed to only 6000 in early May)
  - 12,342 lab-confirmed cases
- Now spread to 34 countries or territories (versus 16 in early May)
  - Includes U.S. territories of Puerto Rico and U.S. Virgin Islands
  - Central America -- Guatemala, Costa Rica, Panama
  - Northern South America -- Columbia, Venezuela, Guyana, Suriname, French Guinea, Brazil
  - Not yet in Cuba or Mexico, but seemingly only a matter of time
- As of 10/7/14 for mainland United States + Hawaii:
  - 1337 cases occurring in 46 states
  - All imported cases except for 11 locally-transmitted cases in Florida (probably by the yellow fever mosquito, *Aedes aegypti*)
  - 4 imported cases to date in Delaware – patients during their 7-day infectious stage need to stay indoors and avoid any bites by our local Asian tiger mosquitoes, *Aedes albopictus*.

Surveillance-and-Monitoring of Mosquito Populations
(key to a successful control program)

- Larval surveillance
  - dip counts in suitable aquatic habitats
- Adult surveillance-and-monitoring
  - Light trap stations (often CO_2 baited -- dry ice)
    - Permanent NJ light trap stations (36 around state)
    - Portable CDC light trap stations
  - Landing rate counts (field inspector counts numbers of adult females landing on front of body in one minute)

Insecticide Controls

- Larvicides preferred (to treat breeding habitats – more localized applications, less exposure for people).

- Adulticides are tools of last resort, but still must often be used (involve more widespread applications, more exposure for people).

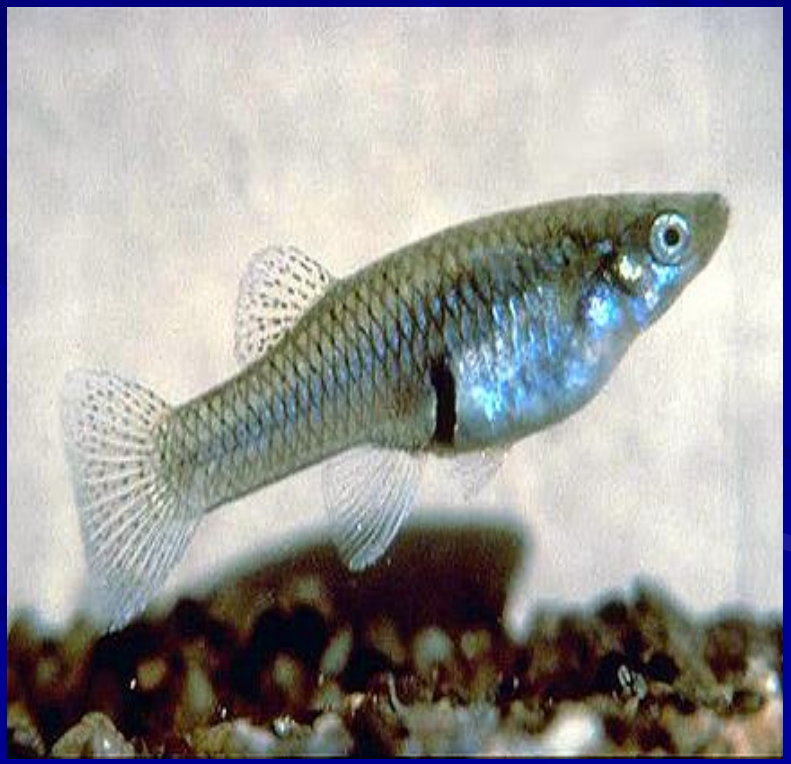
Source Reduction

preferred alternative to insecticide use

- As part of an Integrated Pest Management (IPM) approach to mosquito control, whenever possible and practicable we prefer to use non-insecticide controls.

- Non-insecticide controls occur in Delaware primarily in the form of “source reduction,” whereby we try to prevent, eliminate or reduce mosquito production at its source, in the aquatic larval stages, ***without*** use of chemicals.

Native mosquitofish, *Gambusia holbrooki*, are stocked in stormwater management basins with suitable habitat.



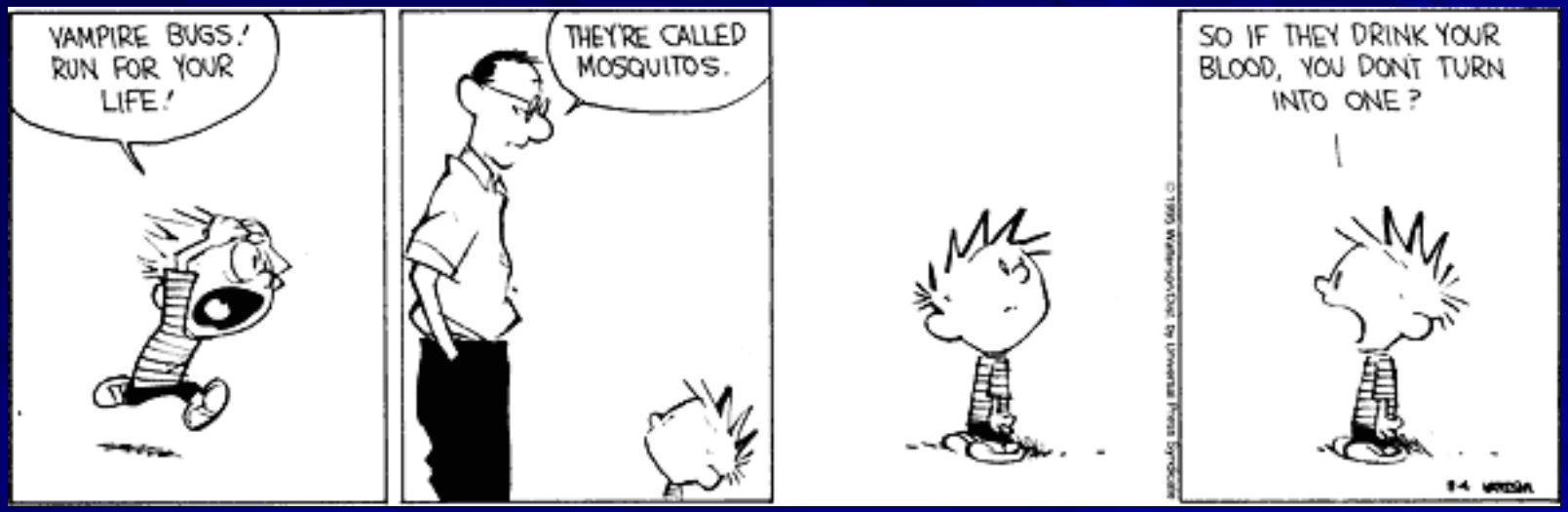

Stormwater Pond,
poor maintenance

This is **NOT** effective mosquito control

they might help, but not ***the*** answer

No bird or mammal preys primarily upon adult mosquitoes. Mosquitoes are minor or incidental dietary components, with not enough consumed for purposes of satisfactory pest relief or acceptable public health protection.

CDC



Thank you. Questions?